MINING HEALTH AND SAFETY UPDATE

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Photo by John J. Haggerty, NIOSH Pittsburgh Research Laboratory

Hazard Recognition Training for Underground Limestone Miners

NIOSH has developed an innovative method to train miners that can help decrease fatalities and injuries.

FROM 1987 to 1996, 13 MINERS were killed at underground stone mines in the United States. In addition, there were 771 injuries resulting in lost workdays. Roof falls caused 12 of the fatalities and 84 of the injuries. NIOSH experts believe that the number of these incidents can be reduced by teaching miners to recognize hazardous ground conditions more effectively.

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The Mining Injury Prevention Branch

THIS ISSUE OF THE *Mining Health and Safety Update* highlights research by the Mining Injury Prevention Branch (MIPB) of the NIOSH Pittsburgh Research Laboratory. The MIPB consists of more than 60 people who address a wide variety of safety issues related to technology and how it is used within the workplace. MIPB researchers encompass a broad range of technical expertise in the social and physical sciences. The goal is to help improve the quality of work life by enhancing the system in which miners work—a system that comprises people, equipment, the work environment, and the organizational culture.

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This issue's focus:

TRAINING
WORK DESIGN

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Hazard Recognition Training for Underground Limestone Miners

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Researchers at the NIOSH Pittsburgh Research Laboratory have developed the *Hazard Recognition Training Program for Underground Limestone* to teach miners to recognize visual cues that indicate poor ground conditions. The training package consists of four three-dimensional (3-D) slide reels and an instructor's guide. It also includes attachments for making overhead transparencies, a true/false quiz, and trainee handouts.

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By viewing the 3-D slides consecutively, the instructor and class "travel" through an underground limestone mine. They view slides of roof and rib conditions while "making their way" down entries and through crosscuts. The slides show examples of ground control concepts, such as:

- Looking for loose rock in the roadway and roof cavities
- Recognizing hazards in reduced visibility conditions
- Assessing hazards by observing scaling tracks
- Evaluating pillar integrity
- Analyzing slips and fractures in the roof and rib
- Recognizing hazards from different vantage points
- Observing cues provided by the placement and integrity of roof bolts

The slides also teach the effects of sand channels and clay veins on roof integrity, hazards associated with newly exposed face areas, and the physics of roof falls (e.g., rocks can fall fast and hit hard).

The instructor's guide provides background information and suggests relevant discussion topics for each slide. Based on these notes, the instructor leads the trainees in a discussion about the hazards depicted in each slide. After all of the slides are viewed, the instructor administers the review quiz and distributes the student handouts. The handouts summarize key points learned in the class. The time required for the training exercise ranges from 1 to 2 hr, depending on discussion.

Most mines provide hazard recognition training by informally discussing hazards or by showing two-dimensional visuals of them. This innovative NIOSH training module advances the traditional approach by using 3-D visuals, specific instructor's notes, and a review exercise. This provides more comprehensive training on recognizing underground limestone mining hazards. In a previous study, it was demonstrated that 3-D slides are effective in teaching miners to recognize geologic and mining-induced hazards (for more information, please request publication No. 1 from the publications listing on page 7 of this *Update*). Miners can "experience" actual workplace conditions because the slides realistically portray the mine environment.

The *Hazard Recognition Training Program for Underground Limestone* can be purchased from the Mine Safety and Health Administration, National Mine Health and Safety Academy, Attention: Office of Academy Services, P.O. Box 1166, Beckley, WV 25802-1166 (phone: (304) 256-3257, fax: (304) 256-3299). The cost is $4.00 for each 3-D slide set (you'll need one set per student) and $1.00 for the instructor's guide. You'll also need a slide viewer for each student, which can be purchased inexpensively at most toy stores. Because all materials are reusable, these are one-time expenses.

The Underground Limestone Training Program was developed under the research project "Hazard Recognition" (K. M. Kowalski, Ph.D., Principal Investigator). All visuals for the program were contributed by John J. Haggerty, Visual Information Specialist. Appreciation is extended to Joe Flick, Assistant Director of Field Services, The Pennsylvania State University, for his assistance in developing the module.

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Slide from the training program depicting a sand channel running through rock.

(Photo by John J. Haggerty, NIOSH Pittsburgh Research Laboratory)

Outby the bolted face that we just looked at,* we see the reasoning behind the decision to bolt the face area.

Why are sand channels/clay veins signals of weakened strata?
How would a sand channel or clay vein weaken rock strata?
What hazards are associated with sand channels or clay veins?
Why should scalers be extra cautious when removing loose rock in these areas?

- Sand channels/clay veins indicate a weakness in the rock.
- The integrity of the rock is lost when sand channels/clay veins are present.
- Special attention when examining these areas is crucial.
- Scalers should pay particular attention to these areas and ensure that they pull down all loose rock and/or secure it by bolting.
- Large sand channels are extremely dangerous and should be called to the attention of management.

Note: Sand channels and clay veins are a concern to limestone miners. They usually indicate that the potential for loose rock is high. The stability of the rock is compromised when these conditions are present. Sand or clay mixed within the rock strata increases the potential for roof and rib falls. Use extra caution when working in areas that have these conditions and communicate to coworkers and management any concerns so that the problem can be corrected and monitored.

*Refers to the previous slide in the program.

Excerpt from the instructor's guide for the sand channel scene above.

Ergonomic Seat for Coal Mine Shuttle Cars

NEARLY ONE-THIRD OF ALL U.S. underground coal mine equipment operators may be exposed to adverse levels of whole-body vibration (WBV). These levels exceed the exposure criteria established by the International Standards Organization. Strong evidence suggests an association between WBV exposure and low-back disorders. NIOSH studies have shown that prolonged sitting, awkward postures, lifting, and other factors may increase this risk. Evidence also shows that shock (jolting or jarring) causes acute injuries. For example, one study abroad found that shock caused 36% of all head, neck, and back injuries involving mobile equipment operators.

Shuttle cars are a major source of WBV exposure and shock because they often travel over rough floor marked by bumps, ruts, and potholes. Although seat suspension systems can help, their use in low-coal mines (48 in or less) is difficult because of space restrictions.

Researchers at the NIOSH Pittsburgh Research Laboratory are developing seats that better meet the physiological needs of equipment operators. A prototype ergonomic seat was recently tested on a shuttle car at a drift mine in eastern Kentucky; its performance was compared with that of the original manufacturer-supplied seat.

Due to the low seam height (operating height was about 43 in), some operators almost had to lie down to drive the car. The original seat provided little lower back support and adjustability. In contrast, the new ergonomic seat

Original shuttle car seat.

New ergonomic seat.

(Photos by Alan G. Mayton, NIOSH Pittsburgh Research Laboratory)

has an adjustable lumbar support and is easier to adjust back and forth. Viscoelastic foams provide padding for shock isolation. The new seat significantly reduced shock when operating a fully loaded shuttle car (improvements were less marked with an empty car). The shuttle car operator described the new seat as generally much better than the original seat: "It's just easy to adjust...and the pad is thicker. It does support you more and [there is] less shock when you hit a hole."

Information about this seat has been distributed to several mining companies and equipment manufacturers. As more feedback from users is received, the design will be refined and other issues will be addressed, such as durability. Researchers are also exploring alternate seat designs and plan to test a second model at a cooperating mine soon.

For more detailed information on the studies discussed here, please request publication No. 8 from the publications listing on page 7 of this *Update*.

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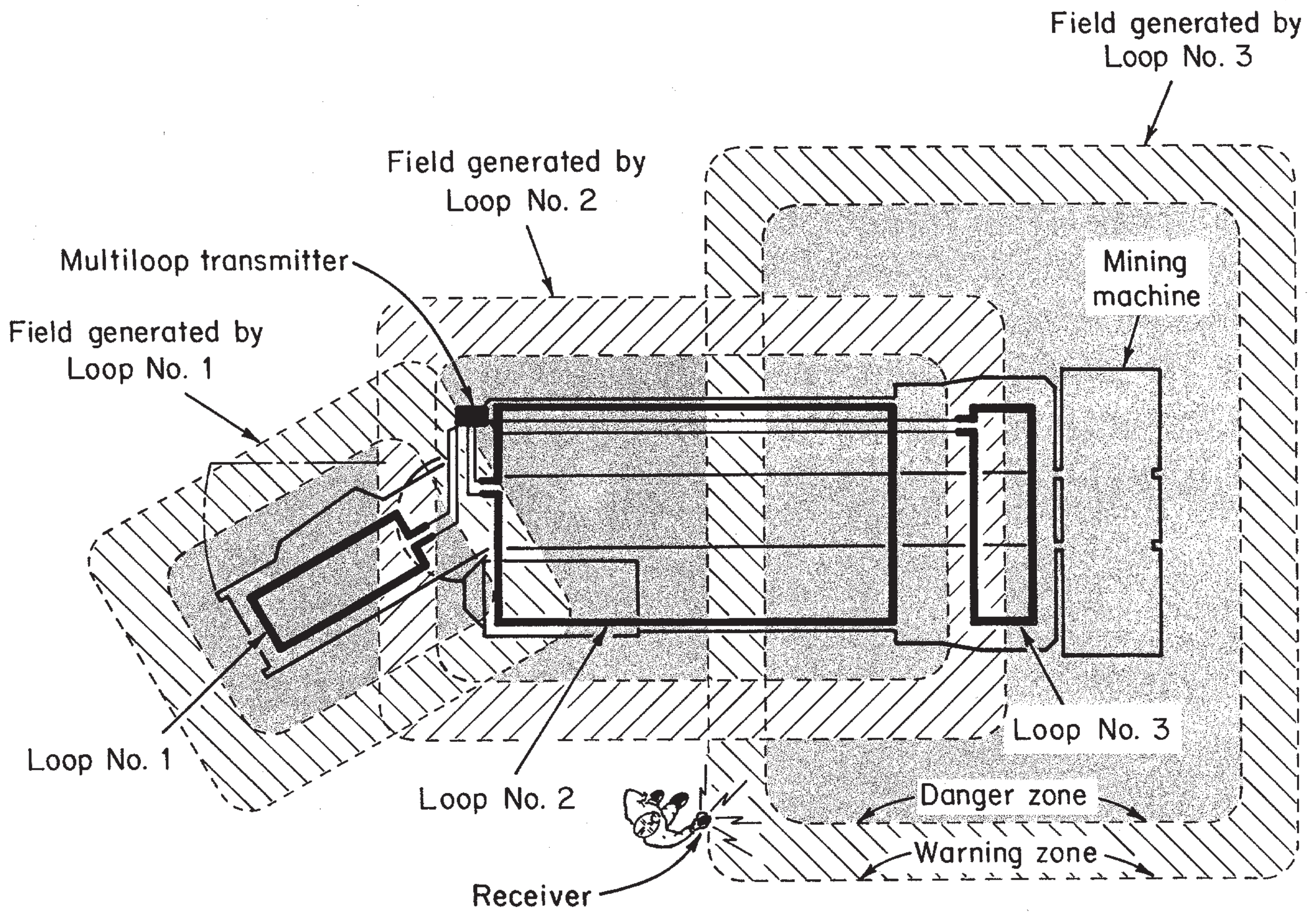
Proximity Detection Device for Remote-Controlled Continuous Miner Operators

OVER THE PAST 3 YEARS, at least four fatalities and many injuries have occurred involving operators of remote-controlled continuous mining machines (RCCMs) and their helpers. Often, the RCCM struck or crushed the workers. In response, the NIOSH Pittsburgh Research Laboratory (PRL) initiated a "Proximity Detection and Collision Avoidance" project. The objectives include studying the habits of operators, determining which areas around mining equipment are dangerous, and developing or acquiring devices that can reduce the hazards.

Researchers identified certain areas around RCCMs that are more dangerous than others. It was generally found that operators know these areas are unsafe. However, when preoccupied with coal production, they often do not notice when they walk into a hazardous area.

Therefore, NIOSH is developing a Hazardous Area Signaling and Ranging Device (HASARD) to reduce the occurrence of these incidents. HASARD is a two-part warning system composed of a



The HASARD system.

transmitter and a receiver. The transmitter generates a low-frequency magnetic field using one or more wire loop antennas. It establishes zones for each hazardous area around the RCCM. By altering the shape of the wire loops and the strength of the transmitter signal, the zones can be molded into virtually any shape. The range of the present transmitter is about 20 ft; however, it could easily be extended with some circuitry changes.

The receiver is a magnetic field strength meter. A small antenna acquires and measures a magnetic field. The system compares this measurement against three preset levels calibrated to identify levels of danger. A "Warning" level indicates to the operator that he/she is approaching a danger zone. A "Danger" level is triggered when the operator actually enters the danger zone. A third level indicates that the HASARD is armed and operational, but all zones are clear.

When a "Danger" level is triggered, the receiver alerts the operator with a combination of visual, audible, and vibration warnings. It also automatically disables RCCM functions, such as tramming. Field trials will determine which indicators are safest and most effective in a mine production environment. For example, the indicators may be mounted on the mining machine operator's hard hat, with the operator's cap lamp used as a flashing indicator.

NIOSH researchers are currently refining a prototype system. Results thus far appear promising and suggest that a viable system is achievable. Initially, researchers plan to test the system aboveground using an in-house RCCM. Later, more testing will be conducted with a second RCCM in PRL's Safety Research Coal Mine. If the tests are successful, additional underground trials will be conducted at a local cooperating mine.

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A Safer System for Mine Hoist Inspections

THE NIOSH PITTSBURGH Research Laboratory has developed a new system for inspecting mine hoists and elevators. This system was designed to address concerns from the Mine Safety and Health Administration (MSHA) and the United Mine Workers of America about the safety of present inspection procedures. For example, in order to take measurements, some tests require the inspector to crawl into the shaft or pit, which can be dangerous.

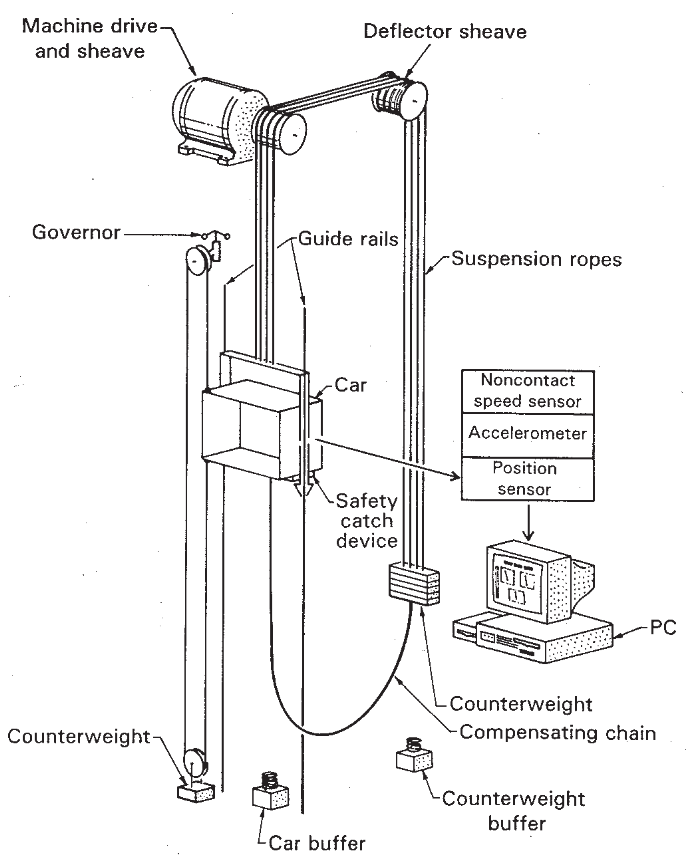
Currently, MSHA Tech Support personnel transport 100-ft cables by truck to a mine site to conduct an inspection. They string these cables from the truck up into the machine room (or "penthouse") above the hoist. Sensors attached to the cables measure electrical parameters, such as speed and acceleration. Data collection equipment inside the truck records the pertinent electrical signals. Typically, this is a chart recorder that traces the signals on paper, producing reams of output.

The new NIOSH method eliminates the truck and cables. Instead, a PC and appropriate hardware are set up in the penthouse to capture and record data. Inspectors can store the data for later analysis, compare the data with prior tests, and perhaps track changes in equipment performance. Also, if certain electrical sensors are absent, inspectors can obtain data through other means. For example, if a tachometer is not available, computer software can derive car speed by mathematically integrating signals from an accelerometer (a device that measures acceleration). With the new NIOSH system, all work occurs in the penthouse. This not only relocates workers from hazardous areas, it also reduces problems in coordinating personnel in different locations.

NIOSH researchers have successfully field tested a computerized data acquisition system and plan to train MSHA electrical inspectors in its use. Software programs are also being developed. The first will allow the mine inspector to record relevant information about a hoist installation. The program will enter that information into a database for archival purposes, then generate a list of suggested tests to conduct. A second program will calibrate a wire rope tester. This device measures the cross-sectional area of the wire suspension ropes, thus indicating abnormal rope wear.

In summary, the new NIOSH system relocates inspectors from dangerous areas, increases inspection efficiency, and improves the quality and tracking of collected data. By recording inspection data digitally, a history of a particular hoist or elevator can be generated. This makes it easier to recognize deterioration in performance before serious problems develop.

Shawn Peterson, Electrical Engineer, (412) 892-4299 (jnp3@cdc.gov). ■



New mine hoist inspection system.

Recent Mining Health and Safety Publications

1. Barrett EA, Kowalski KM [1995]. Effective hazard recognition training using a latent-image, three-dimensional slide simulation exercise. Pittsburgh, PA: U.S. Department of the Interior, Bureau of Mines, RI 9527.

2. Barrett EA, Rethi LL [1998]. Underground hazard recognition training. Aggregates Manager 2(11):30-33.

3. Brnich MJ Jr., Mallett LG, Vaught C [1997]. Training future mine emergency responders. Part 1: Who should be trained and how? Part 2: What topics should be included? Falls Church, VA: U.S. Department of Labor, Mine Safety and Health Administration, Holmes Safety Association Bulletin *Oct*:3-5; *Nov*:3-5.

4. Cornelius KM, Turin FC [1997]. A case study examining cumulative trauma exposure of coal mine workers. In: Das B, Karwoski W, eds. Advances in Occupational Ergonomics and Safety II. IOS Press and Ohmsha: pp. 569-572.

5. Dubaniewicz TH, Kovalchik PG, Scott LW, Fuller MA [1998]. Distributed measurement of conductor temperatures in mine trailing cables using fiber-optic technology. In: IEEE Transactions on Industry Applications. Vol. 34, No. 2, pp. 395-398.

6. Fotta B, Mallett LG [1997]. Effects of mining height on injury rates in U.S. underground nonlongwall bituminous coal mines. Pittsburgh, PA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 98-104, IC 9447.

7. Kovalchik PG, Scott LW, Duda FT, Dubaniewicz TH Jr. [1997]. Investigation of ampacity derating factors for shuttle cars using fiber optics technology. In: Proceedings of the IEEE-Industrial Applications Society 32nd Annual Meeting.

8. Mayton AG, Gallagher S, Merkel R [1997]. Ergonomic seat with viscoelastic foam reduces shock on underground mobile equipment. In: Das B, Karwoski W, eds. Advances in Occupational Ergonomics and Safety II. IOS Press and Ohmsha: pp. 177-180.

9. Mayton AG, Merkel R, Gallagher S [1998]. Shock reduction for low-coal shuttle car operators using viscoelastic seating foam. SME preprint 98-44.

10. NIOSH [1997]. Technology News 455: Roof hazard alert modules. Pittsburgh, PA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

11. NIOSH [1997]. Technology News 459: Ergonomic seat reduces shock for low-seam shuttle car operators. Pittsburgh, PA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

12. NIOSH [1997]. Underground mine fire preparedness. Part 1: Study overview and perspective of underground mine fires. Part 2: Preparedness to evacuate and miners' experiences with incipient fires. Part 3: Fire-fighting experiences and workers' perceptions of training and readiness for fire-fighting. Part 4: Suggested improvements and implications for training miners in fire-fighting preparedness. Falls Church, VA: U.S. Department of Labor, Mine Safety and Health Administration, Holmes Safety Association Bulletin *May-June*:14-19; *July*:1-4; *Aug*:3-7; *Sept*:3-10.

13. Sammarco JJ, Kohler JL, Novak T, Morley LA [1997]. Safety issues and the use of software-controlled equipment in the mining industry. In: Proceedings of the 1997 Australian Workshop on Industrial Experience With Safety Critical Systems and Software. Australian Computer Society: pp. 25-32.

14. Schiffbauer WH [1997]. Accurate navigation and control of continuous mining machines for coal mining. Pittsburgh, PA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 98-101, RI 9642.

Free copies of the above publications may be obtained by contacting Diane M. Felice, phone: (412) 892-4411, fax: (412) 892-6877, e-mail: def9@cdc.gov. Please order by specifying publication number (1 through 14).

Many of our publications can also be accessed through our Common Information Service System (CISS) site on the Internet at http://outside.cdc.gov:8000/ciss/Welcome.html

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Upcoming Presentations (Mining Injury Prevention Branch)

May 9-15, 1998 • American Industrial Hygiene Conference and Exposition, Atlanta, GA (registration: Carol Tobin, 2700 Prosperity Ave., Suite 250, Fairfax, VA 22031, (703) 849-8888, infonet@aiha.org). *Case study: an improved seat for underground mobile equipment* (S. Gallagher, A. Mayton, R. Merkel).

May 19-22, 1998 • The International Emergency Management Society (TIEMS) Conference, Washington, DC (registration: Greg Shaw, The George Washington University, (703) 729-8271). *Training to improve emergency communication skills* (L. Mallett, M. Brnich, C. Vaught).

June 9-11 and September 1-3, 1998 • Open Industry Briefing on Mine Fire Preparedness, NIOSH Lake Lynn Laboratory, Fairchance, PA (registration: Ron Conti, (412) 892-4262, rkc4@cdc.gov, or Linda Chasko, (412) 892-6854, ljc6@cdc.gov). *Overview of mine emergency response training research* (C. Vaught and M. Brnich), *Workshop on miners' experience in fighting small underground mine fires* (W. Wiehagen, B. Fotta, C. Vaught, R. Conti), *Who, what, and where: the communication triangle of fire* (L. Mallett), *The mine emergency response interactive training simulation* (A. Glowacki, L. Rethi), *Trapped miner location system and coal miners' communication system* (W. Schiffbauer).

June 11-13, 1998 • XIII Annual International Society for Occupational Ergonomics and Safety Conference 98, Ann Arbor, MI (registration: Shrawan Kumar, Ph.D., 3-75 Corbett Hall, University of Alberta, Edmonton, Alberta, Canada, T6G 2G4, (403) 492-5803, shrawan.kumar@ualberta.ca). *The effects of vertical space restriction on the moment experienced by the lumbar spine* (S. Gallagher, C. Hamrick, K. Cornelius, M. Redfern).

September 21-25, 1998 • International Symposium on Hazards, Prevention, and Mitigation of Industrial Explosions, Schaumburg, IL (registration: C. James Dahn, Safety Consulting Engineers, Inc., 2131 Hammond Dr., Schaumburg IL 60173, phone: (847) 925-8100, fax: (847) 925-8120). *Ignition of methane-air mixtures by laser-heated small particles* (T. Dubaniewicz, K. Cashdollar, G. Green).

To receive additional information about mining issues or other occupational safety and health problems, call 1-800-35-NIOSH (1-800-356-4674), or visit the NIOSH Home Page on the World Wide Web at http://www.cdc.gov/niosh

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